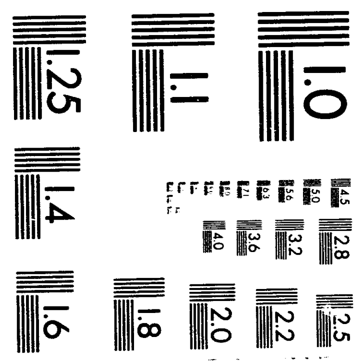

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DOE/PC/92521--T123

TECHNICAL REPORT
September 1 through November 30, 1993

Project Title: **WASHABILITY OF TRACE ELEMENTS IN PRODUCT COALS FROM ILLINOIS MINES**

DOE Grant Number : DE-FC22-92PC92521(YEAR2)
ICCI Project Number : 93-1/6.2A-1P
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Project Manager : K. K. Ho, ICCI

ABSTRACT

The existing trace element washability data on Illinois coals are based on float-sink methods, and these data are not applicable to modern froth flotation or column flotation processes. Particularly, there is a lack of washability data on samples from modern preparation plants, as well as other product (as-shipped) coals. The goal of this project is to provide the needed trace element washability data on as-shipped coals that were collected during 1992-1993 from Illinois mines. The results generated by this project will promote Illinois coals for such prospective new markets as feed materials for advanced gasification processes, for synthetic organic chemicals, and to meet new environmental requirements for their use in utility steam generation.

During the first quarter, each of 34 project samples were ground to about -100 mesh size and cleaned by use of a special froth flotation technique (release analysis). The flotation products were analyzed for ash, moisture, and heating value (BTU). The data were then used to construct a series of different washability curves. For example, these curves can show variation in BTU or combustible recovery as a function of the amount of ash or S rejected, or as a function of the weight of the flotation products. From the relationship between %cumulative BTU and %cumulative weight, nine composite samples each having 80% of the total BTU were prepared from the individual flotation products and submitted for trace element analysis. The composite samples for the remaining 25 of the 34 -100 mesh flotation runs will be submitted soon and the analytical results are expected to be available in 3-4 months. The results from trace element analyses of the composite samples with 80%-BTU recovery will indicate the potential removal of each element from the coals at the flotation conditions and particle size used.

Splits of all 34 project samples were also ground to -200 mesh and initially processed for release analysis. Particle size and chemical analyses tasks for these samples are in progress.
"U. S. DOE Patent Clearance is **NOT** required prior to the publication of this document."

EXECUTIVE SUMMARY

The goal of this project is to provide new and advanced trace element washability data on product (as-shipped) coals from Illinois mines. The results will indicate how much further advanced cleaning techniques can reduce the trace element levels in the marketable coals that have already been cleaned with conventional cleaning techniques. With the advent of new and improved technologies and expanding possibilities for reaching foreign markets, the availability of advanced washability data would help promote Illinois coal products. The project results will provide advanced washability data for evaluation of trace element emissions at power generating plants. In addition, the results will facilitate national and international recognition of further processability of product coals from Illinois to be used as feed materials for advanced gasification processes and for production of synthetic organic chemicals.

Given the sensitive nature of the data to be generated by this project, only averages of the results for multi-county regions of the state will be reported. The results on individual mines may also be reported only by withholding the identity and location of the mines.

During the first quarter of the project, all 34 project samples were ground to about 90% -100 mesh size in a Holmes mill. All the -100 mesh samples were subjected to froth flotation cleaning using a release analysis procedure. The chemical analyses of all the flotation products for ash, moisture, and heating value (BTU) were completed.

The data from release analysis of the flotation products (5 concentrates plus tail)were used to construct a series of different washability curves. For example, washability curves for BTU or combustible recovery as a function of the amount of ash or S rejected, or as a function of the weight of the flotation products, can be generated.

From one of washability curves indicating relationship between % cumulative BTU or combustibles and %cumulative weight of flotation products, composite samples (each having 80% of the total BTU) were prepared. To date, nine such composite samples have been prepared from the -100 mesh flotation runs and submitted for trace element analysis. It is anticipated that the remaining 25 composite samples for the -100 mesh runs will be submitted soon and the resulting analyses available in 3-4 months. These data will then be compared to trace element data obtained previously on the as-shipped coals. The results from trace element analyses of the 80%-BTU recovery composite samples will indicate the potential beneficiation for each element at these generalized flotation conditions and mesh size used.

Although all 34 samples have also been ground to about 90% -200 mesh size and initially processed for froth flotation cleanability, all the particle size and chemical analyses results have not been completed or confirmed. Some of the cleanability runs for the -200 mesh samples need to be repeated. The results on the -200 mesh samples will be reported in the next quarterly report.

OBJECTIVES

The main objective of this project is to generate advanced trace element washability data on available coals or other types of marketed material from operating mines in Illinois. The availability of trace element washability data will permit a wide variety of advanced engineering and environmental calculations, such as improved capabilities to match specific coals for optimum processes for 1) prospective markets as feed materials for advanced gasification processes and for synthetic organic chemicals, and 2) management of environmental requirements for noxious emissions at power generating plants.

To meet the stated objective the following specific tasks were identified.

1. Quality control/quality assurance. A comprehensive quality assurance quality control plan, already in place for ISGS work, are modified and made specific to all phases of this project.

2. Sample preparation. We already collected all the samples needed for this project. The samples are currently stored under nitrogen gas in our laboratory. Representative splits of the samples are ground to three different sizes (-100 mesh, -200 mesh, -400 mesh) for the proposed washability tests.

3. Washability tests. This research project will evaluate the trace element washability of coal at fine to ultrafine particle sizes with special regard for their industrial application.

4. Analyses of the products from washability tests for moisture, ash, heating value, and trace elements.

INTRODUCTION AND BACKGROUND

With the advent of new and improved technologies and expanding possibilities for exporting to foreign markets, and with recent environmental legislation, the availability of trace element washability data would help promote Illinois coal products. The data generated by this project will enhance the knowledge that could be provided to coal-producing and -utilization companies and help open up new markets and possibilities for the utilization of Illinois coals. The data will also be useful for an initial environmental evaluation that is needed in response to new federal air quality legislation.

The levels of washability efficiency obtained by traditional density or float-sink separation of fine coal in the laboratory may not be achievable by industrially practicable cleaning procedures. It is important, therefore, to develop a washability database that has industrial application. The washability testing process we use has potential economic and commercial feasibility. The proposed process utilizes multi-stage flotation in a standard sub-aeration flotation cell to generate washability curve, which have been demonstrated to correlate to industrially feasible cleaning procedures, namely froth flotation and column flotation.

Related Research

Trace elements in coal. A study by the U.S. National Committee [National Research Council for Geochemistry (NRC) [1980] discussed the potential health hazards of various trace elements that might be encountered during the development and utilization of coal. The Committee identified three categories of elements of environmental concern with respect to coal:

Of greatest concern - As, B, Cd, Pb, Hg, Mo, and Se

Of moderate concern - V, Cr, Ni, Cu, Zn, and F

Of minor concern - Li, Na, Sr, Ba, Mn, Co, Ge, Cl, Br, and radioactive elements Ra, Po, Rn, Th, and U

These judgments were based upon known toxicity, levels of occurrence of each element in coal, and the anticipated mobility upon combustion or disposal of ash. These recommendations are only guidelines and eventual emission standards should be based on valid biological data.

The Clean Air Act of 1990 [Public Law 101-549, 1990] lists 18 trace elements as "Hazardous Air Pollutants" (HAP): As, Be, Cd, Cl, Cr, Co, F, Hg, Mn, Ni, Pb, Po, Ra, Rn, Sb, Se, Th, and U. A parallel regulation is also underway in Illinois [Illinois Pollution Control Board, 1990]. All of these HAP elements are present in Illinois and other coals [Gluskoter et al., 1977; Swanson et al., 1976; Zubovic et al., 1979, 1980; Cahill et al., 1982; Harvey, et al., 1985] and their concentrations vary considerably. Utilities are presently exempt from having to comply; however, this may eventually change after the U.S. EPA completes its risk studies and establishes emission standards as prescribed by law. This process may take some time (2-10 years?), but eventually emission limitations on all or some of these elements will likely be imposed. The ultimate burden to coal-burning utilities may eventually be to determine the amounts of each

HAP element actually being emitted to the atmosphere for a particular coal under the combustion conditions in which they operate.

For some elements during combustion, there can be significant losses [Klein et al., 1975]. Their mass balance studies on the Allen cyclone boiler power plant at Memphis, Tennessee, using coals from Illinois and western Kentucky, indicated that most coal-derived Hg, some Se, and probably most Cl and Br are released as gases to the atmosphere. The elements As, Cd, Cu, Ga, Mo, Pb, Sb, Se, and Zn were concentrated in the fly ash and are partially released to the atmosphere by this mechanism. The electrostatic precipitator removed about 96.5-99.5% of the fly ash on the two runs that were tested. Kaakinen et al. [1975] measured the concentrations of 17 elements in a mass balance study of a power plant fueled with a western coal. The elements Pb, Cu, Zn, As, Mo, Hg, and Se were found to be partly volatile. Natusch et al. [1974] independently observed that certain elements, especially As, Sb, Cd, Pb, Se, and Tl, are more concentrated on the smaller, respirable-sized fly ash particles.

Swaine [1989] reviewed some environmental aspects of trace elements in coal. With respect to combustion, modern electrostatic precipitation systems are able to trap up to 99% of the fly ash. Thus, trace elements that "escape" during combustion are either attached to ultra small fly ash particles or in a gaseous state. Swaine concluded that, in general, no trace element posed a significant environmental problem. This assumes the use of state-of-the-art electrostatic precipitators and only burning coals with no exceptionally high concentrations of any noxious element that would be emitted in a gas phase or attached to untrapped fly ash particles that pass through electrostatic precipitators.

Removal of trace elements from coal. Over the years a number of studies have resulted in the evaluation of trace element removal from coal as a result of the particular cleaning method utilized. Most certainly deep physical cleaning of coal should significantly reduce the level of most trace elements [Gluskoter et al., 1977; Cavallaro et al., 1978; Harvey et al., 1983] as shown by float/sink testing. However, there has been a lack of data on the trace element washability of product coals from modern preparation plants. In general, physical cleaning is limited and only becomes efficient (70-90% removal) if a high degree of comminution is utilized, freeing the mineral matter from the macerals. Those trace elements organically bound or associated with the macerals are not removed; their concentrations are actually enhanced in the cleaned coal. Studies tracking trace element removal using chemical means indicate good removal; however, costs would be quite high.

Our literature search found no data available for trace element removal using microbial methods. Brierley and Brierley [1981] reported on recovery of metals from ores and sulfur from coal via microbial action. Trace element removal would be highly dependent upon removal of the host mineral in coal.

Various reviews have summarized progress in the removal of trace elements via coal cleaning practice. These include Jacobsen et al. [1992], Norton et al. [1992], Kaiser Engineers [1989], Norton et al. [1989], Streeter [1986], Norton et al. [1985], Wheelock and Markuszewski [1981, 1984], National Research Concil [1980], National Academy of Science [1979], and Mezey [1977].

Float-sink gravity separation studies have shown that significant reduction can be achieved for some trace elements through conventional coal cleaning; however, the coarse particles (~ 3/8") generally limit the amount of liberation. Extensive work done at the ISGS by Harvey et al. [1983], Fiene et al. [1979], and Gluskoter et al. [1977] on Illinois coals indicate many elements (As, Ba, Ca, Cd, Fe, Mn, Mo, Pb, Tl, and Zn) have strong inorganic association and at 80% recovery can be significantly (~ 50% or greater) removed. Other elements (B, Be, Ge, Ni, Sb, U, and V) are strongly associated with organic matter and are generally not removed by physical cleaning. The behavior of some 32 other elements during float-sink separation indicated mixed association. Kuhn et al. [1980] similarly characterized an eastern seam (Pittsburgh 8) and a western seam (Rosebud), indicating differences in trace element/mineral association and possible cleaning potential. For example, in the Rosebud coal, Sb was classified to be associated with the organic fraction, not with the inorganic fraction (as with Illinois Basin coal). Cavallaro et al. [1978] reported on the float-sink behavior of some eight elements (Cd, Cs, Cu, F, Hg, Mn, Ni, and Pb) in 10 coals from various producing areas of the U.S. Results indicated that although the concentration of individual trace elements in the feed coal varied from region to region and within a region, the removal of the heavier fraction (> 1.6 S.G.) would result in significant reduction in the 14-mesh clean coal product for all the coals tested. The data indicated that 64 to 88% composite trace element concentrations were in the 1.6 S.G. sink fraction depending upon the geographical region.

Akers and Dospay [1992] presented results from washability data on an Upper Freeport coal for As and Ni at several size fractions indicating better removal at the smaller sizes. They also presented data on reductions for some 10 trace elements for four coal seams at several energy recoveries using conventional gravity separations.

Ford et al. [1976] demonstrated that rough coal cleaning at a top size of 30 mesh via a concentrating table was effective in partially removing Hg, Pb, As, Mn, and Se from eight diverse coal types. The percentage ranges of removal were reported for Hg (3-68%), Pb (8-63%), As (11-67%), Mn (9-76%), and Se (2-61%). Ford and Price [1980] reported on results of conventional as well as non-conventional coal cleaning of some 20 run of mine coals. The elements As, Cd, Cr, Co, Cu, F, Pb, Mn, V, Zn and most major ash elements were significantly removed. Ford and Price [1982] reported on trace element removal via heavy media cyclone cleaning. Averages of the % original amount of trace elements that remained in clean coal fractions for four Appalachian and two midwestern coals were as follows: As (53), B (98), Be (75), Cd (54), Co (63), Cr (60), Cu (60), F (49), Hg (89), Mn (37), Ni (62), Pb (32), Sb (91), Se (67), V (76), Zn (51). Conzemius et al. [1988] determined the fate of 75 elements after cleaning via heavy medium cyclone. Although the concentrations of most elements followed the ash content, the cleaned coal was enriched in Be, Mo, U, I, Co, and Sb.

Kulinenko and Barma [1990] used a combination of screening, density separation, jigging, flotation, centrifugation and vacuum filtration and monitored some 29 trace elements in the various streams. Arsenic and Hg were most abundant in jigging refuse. Fluorine and Ga were most abundant, and Hg, Be, and Ge were least abundant, in density separation refuse. Cesium was least abundant in flotation refuse.

Capes et al. [1974] followed the disposition of certain trace elements during separation by oil agglomeration. Levels of As, Cs, Pb, Mn, Mo, Ni, and V were reduced by 50-80%. Knott et al. [1985] reported on trace element reduction comparisons obtained by oil agglomeration, froth flotation, and float-sink processes on Australian coals. The OTISCA process, an oil agglomeration approach utilizing a fluorocarbon liquid (freon), [Jacobsen et al., 1992] indicated >90% removal of As, Cd, and Pb from coal.

A combination process of froth flotation and oil agglomeration called "aggregate flotation" was able to remove greater than 50% of Cd, Co, Cr, Li, Mn, Na, Sb, Sr, Th, and V from Illinois coals [Buckentin et al., 1985].

A combination of heavy media cyclone or table separation and advanced froth flotation approach utilizing microbubble processing on fine size Illinois coal [Bechtel National, Inc., 1988] achieved over 80-90% removal for As, Be, Co, F, Ni, Pb, Sb, Th, U, Cr, and Sc.

The LICADO process [Jacobsen, et al., 1992] based upon surface-separation using liquid CO_2 indicated only moderate separation for As, Ni, and Pb.

Limited trace element data for two caustic leaching processes (the Battelle hydrothermal and TRW/Molten-caustic leaching) [Jacobsen et al. 1992] show high removal of Pb but mixed reduction for Cd, Ni, Se, and As. Data on the Battelle Alkaline Desulfurization process for three Ohio coals indicate high (> 70%) removal for Li, Ba, Be, B, K, P, Mo, V, As, and Ba [Mesey, 1977; Stambaugh et al. 1979].

The Jet Propulsion Laboratory chlorinolysis process is run at 50°-100° C, passing chlorine gas through a fine-ground slurry of coal, organic solvent, and water [Jacobsen et al., 1992; DuFresne and Kalvinskas, 1980]. Trace element removal data that were available for As, Cd, Hg, Pb, and Se indicated mixed success; high removal for Pb, medium removal for As, and low removal for Cd, Hg, and Se.
The Meyers process [Mesey, 1977; Hamersma et al., 1974] uses and regenerates $Fe_2(SO_4)_3$ and is said to effectively remove pyrite. In a study of some western, eastern interior, and Appalachian coals, As, Zn, Cd, Pb, Ni, Mn, Cr and other elements normally known to be associated with pyrite and other minerals were significantly reduced. The data available for B, Be, Cu, F, Hg, Li, and V indicated somewhat mixed removal capability.

Norton et al. [1986] reported on the comparative treatment of the Herrin (Illinois No. 6) coal using molten NaOH/KOH or 1.0 M Na_2CO_3 addition under elevated temperature/pressure conditions followed by acid wash. Levels of Mn, Pb, Rb, Sr, and Zn were lowered by 75% or more, while those of Ba, Cd, Cr, Ni, Se were lowered by 30-60%. They also reported on results obtained by the TRW Gravimelt process where the levels of As, Be, Cd, Hg, Pb, Se, and Sr were reduced by 75% or more. Kuhn et al. [1980] reported on "mineral free" values of some 52 trace and minor elements in eastern and western coals that were subjected to float-sink separation and extensive extractions with dilute HNO_3 and HF, followed by washing with water. This characterization (not intended to be a practical cleaning) approach indicates the amount of organic-associated trace elements that would remain in the coal after an exhaustive physical and chemical cleaning.

We started a project in 1992, with the support of the ICCI, to generate current data on trace elements in product coals from operating mines in addition to compiling existing data for the evaluation of Illinois coals for HAP emissions [Demir et al., 1993]. Thirty four product coal samples from operating Illinois mines were collected, processed, and analyzed for trace, minor, and major elements. These coal data will be useful in predicting the highest order of magnitude (worst scenario) for individual trace element emissions that would be derived from burning various Illinois coals. This current project characterizes the washability of 29 trace elements of some environmental concern in all 34 product coals that were produced at commercial preparation plants by processing outputs from operating Illinois mines. Because of the proprietary nature of the data, average values will be reported for at least 4 multi-county regions of the Illinois coal field and individual mine results will be reported only with sequential sample numbers. The mine name and location are to be held confidential.

EXPERIMENTAL PROCEDURES

Preparation of -100 Mesh Samples

All samples used during this quarter were splits obtained from dry grinding with the Holmes mill in conjunction with a -60 mesh screen. Each sample was subsequently analyzed for particle size distribution on a Microtrac particle size analyzer which indicated generally that about 90% of the ground material was -100 mesh.

Froth Flotation and Release Analysis of -100 Mesh Samples

During this period all 34 -100 mesh samples were cleaned through froth flotation using the "release analysis" technique (Dell,1964 and Forrest,1990). Figure 1 indicates the systematic series of sequential flotations performed in order to obtain 5 concentrates and 4 tails(the tails are eventually combined for analysis) having different concentrations of ash and trace elements. A representative split (300 grams, dry basis) was slurried with about 3.5 liters of water in a conventional Denver froth flotation cell, conditioned with 0.4 ml of kerosene, 0.4 ml of frother (2- ethylhexanol) added, and approximately 6 liters of air per minute passed through the cell with the rotor set at 1200 rpm. The resulting float fraction was repulped and floated three times (adding 0.1 ml additional frother) and the corresponding sinks collected. The resulting float from the third flotation was again repulped and then refloated, taking 20 second samples (C1, C2, etc.) using an increasing amount of air (2 to 7 liters) for each concentrate taken. This procedure generates the most beneficiated sample (C1) and progressively the less beneficiated samples (C2, C3, etc.) in addition to the lower grade tails (S1, etc.).

Each sample of the flotation products was submitted and analyzed for ash, moisture, heating value (BTU), and total sulfur in accordance with established ASTM procedures [ASTM, 1992].

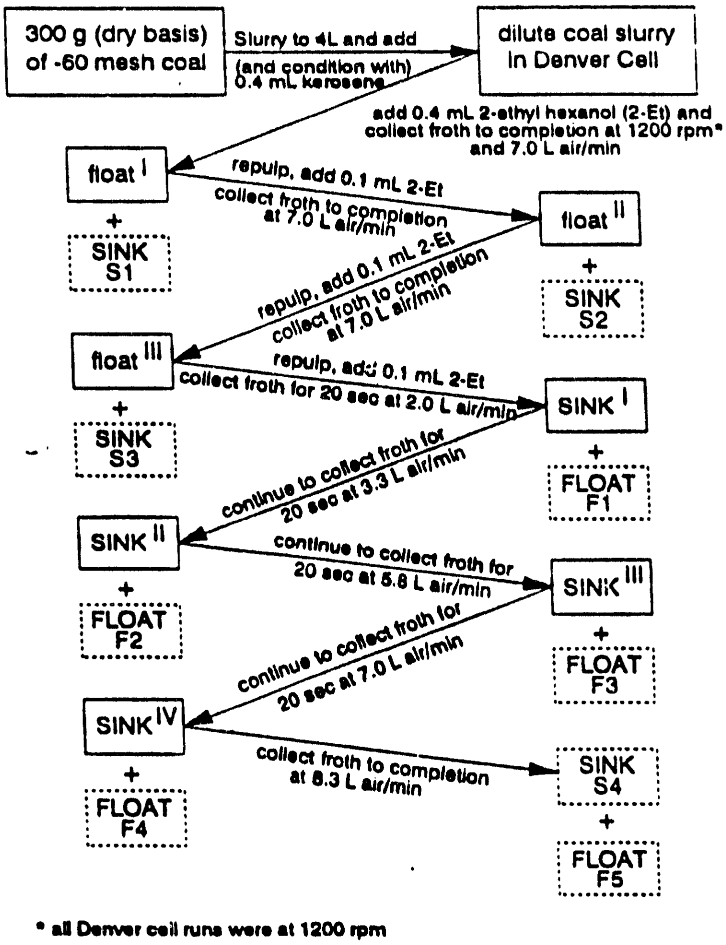

Figure 1. Froth flotation and release analysis approach.

Preparation and Froth Flotation of -200 Mesh Samples

All samples used for this task were representative splits from the -4 mesh samples set aside under nitrogen for rheology tests. About 700 grams of coal in each case was mixed with 700 grams of water and ground in a rod mill for 30 minutes. The coal slurry was filtered, split in half, and a one half fraction was cleaned using the same froth flotation, release analysis procedure that was used for the -100 mesh samples with a few reagent concentration changes. In general 0.7 ml kerosene was used along with 0.5 ml frother in the first flotation. In some cases additional kerosene had to be used in order to wet the coal and prevent excess amounts of tails. A split of the grinding product(feed for the -200 mesh froth flotation test) was tested for particle size distribution. In general those samples tested in the range of 90% passing -200 to 270 mesh. Several tested in the range of 90% passing -325 mesh and 80% passing -500 mesh.

RESULTS AND DISCUSSION

Preparation of -100 mesh Samples

All 34 project samples were dry-ground by a Holmes mill to about 90% -100 mesh size (Table 1) to provide feeds for the froth flotation (release analysis) tests.

Table 1. Particle size analysis of product coals ground in a Holmes mill.

Lab No.	Coal Region*	90%passing micron size	90% passing U.S. Mesh size	Average micron size	80% passing U.S. Mesh size
C32773	1	139	100	65	120
C32774	1	165	80	83	120
C32777	1	143	100	67	120
C32778	1	130	100	63	120
C32782	1	150	100	72	120
C32783	1	206	70	81	120
C32785	1	188	80	89	120
C32797	1	171	80	84	120
C32814	1	189	70	90	120
C32779	2	153	80	75	120
C32794	2	175	80	90	120
C32798	2	130	100	61	120
C32800	2	191	70	91	80
C32813	2	177	80	88	120
C32815	2	171	80	83	120
C32784	3	172	80	34	120
C32795	3	157	80	75	120
C32796	3	179	80	83	120
C32799	3	168	80	78	120
C32801	3	127	100	64	120
C32802	3	124	120	58	170
C32803	3	142	100	68	120
C32661	4H	153	100	71	120
C32664	4H	220	70	101	80
C32665	4H	127	100	60	120
C32771	4H	143	100	69	120
C32776	4H	166	80	79	120
C32662	4S	183	80	85	120
C32663	4S	169	80	77	120
C32772	4S	122	120	58	170
C32775	4S	171	80	76	120
C32780	4S	270	50	95	80
C32781	4S	124	120	54	170
C32793	4S	201	70	79	120

* 1, NW region; 2, SW region; 3, SC region; 4H, SE-Herrin Coal region; 4S, SE-Springfield Coal region. See also Demir et al. [1993].

Washability Curves for -100 mesh Samples

The -100 mesh samples were subjected to froth flotation cleaning using a release analysis procedure described in the experimental procedures section.

The data from release analysis of the flotation products are being used to construct a series of different washability curves. An example of a washability curve for ash is given in Figure 2 indicating that for 80% of the BTU or combustibles recovered only about 48% of the ash is retained (or 52% of the ash has been removed). A similar curve is shown for sulfur in Figure 3 where a composite sample containing 80% of the original BTU content would have about 67% of the total sulfur of the original feed coal. Although the 52% of the ash removed would have also contained a significant amount of the pyritic sulfur (it was not analyzed) there still is a considerable amount of organic sulfur (2.45%) in the feed coal which is not removed under these physical separation conditions.

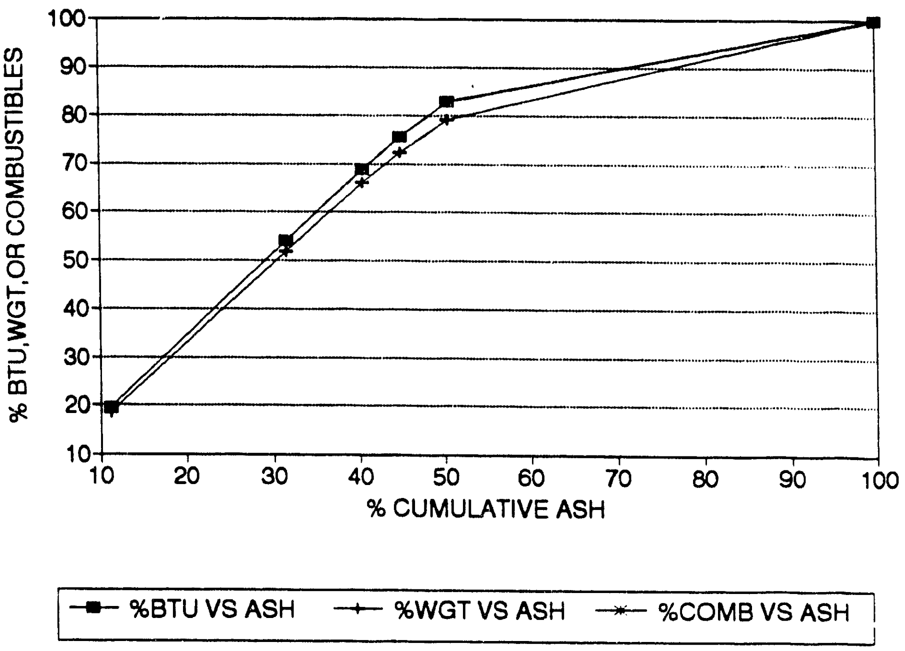

Figure 2. Cumulative washability curve for ash rejection for sample C32782 ground to -100 mesh.

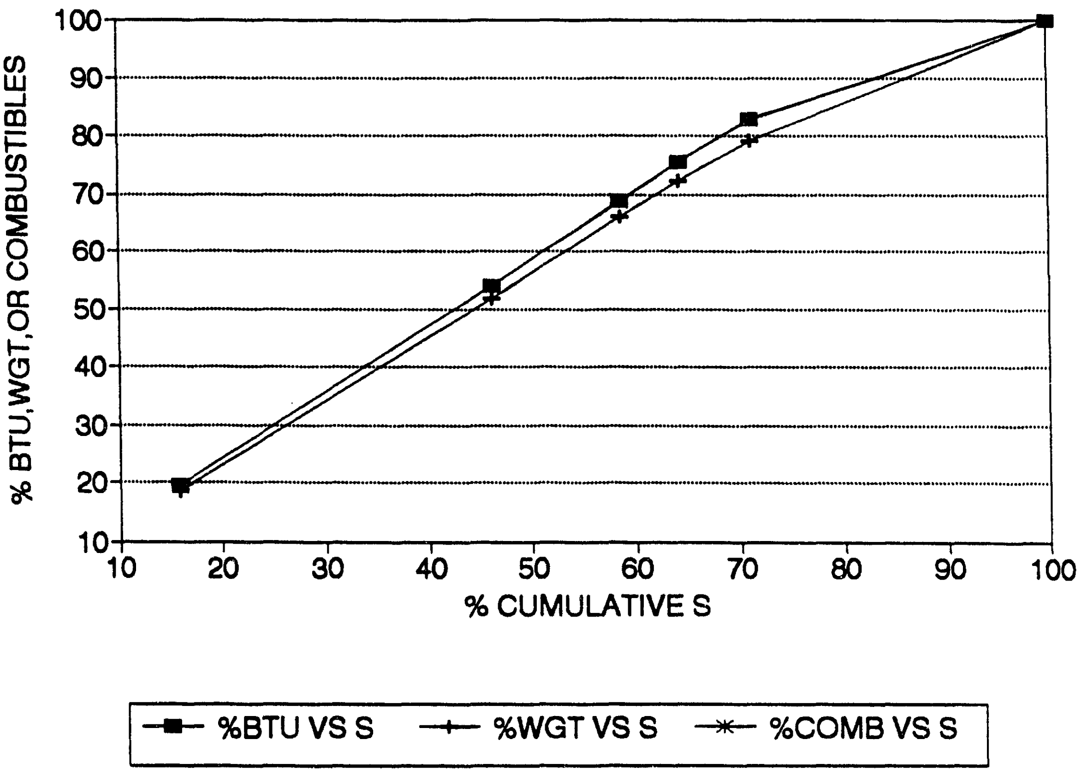

Figure 3. Cumulative washability curve for sulfur rejection for sample C32782 ground to -100 mesh.

Composite Samples of Flotation Products for Trace Element Analysis

From one of the washability curves (Fig. 4) indicating the relationship between % cumulative BTU or combustibles(100- % ash -%moisture) and % cumulative weight, it is possible to construct a composite sample (each having 80% of the total BTU) from the individual concentrates (C1, C2, etc.) for submission for trace element analysis. For example Figure 4 indicates that for sample C32782 all of C1, C2, C3, C4 and about 55% of C5 are required to construct the 80% BTU composite. As seen in Figure 4, the BTU and combustibles curves are almost identical. This has been observed in all the samples thus far and will permit the use of ash analysis alone to construct these composite samples, eliminating the

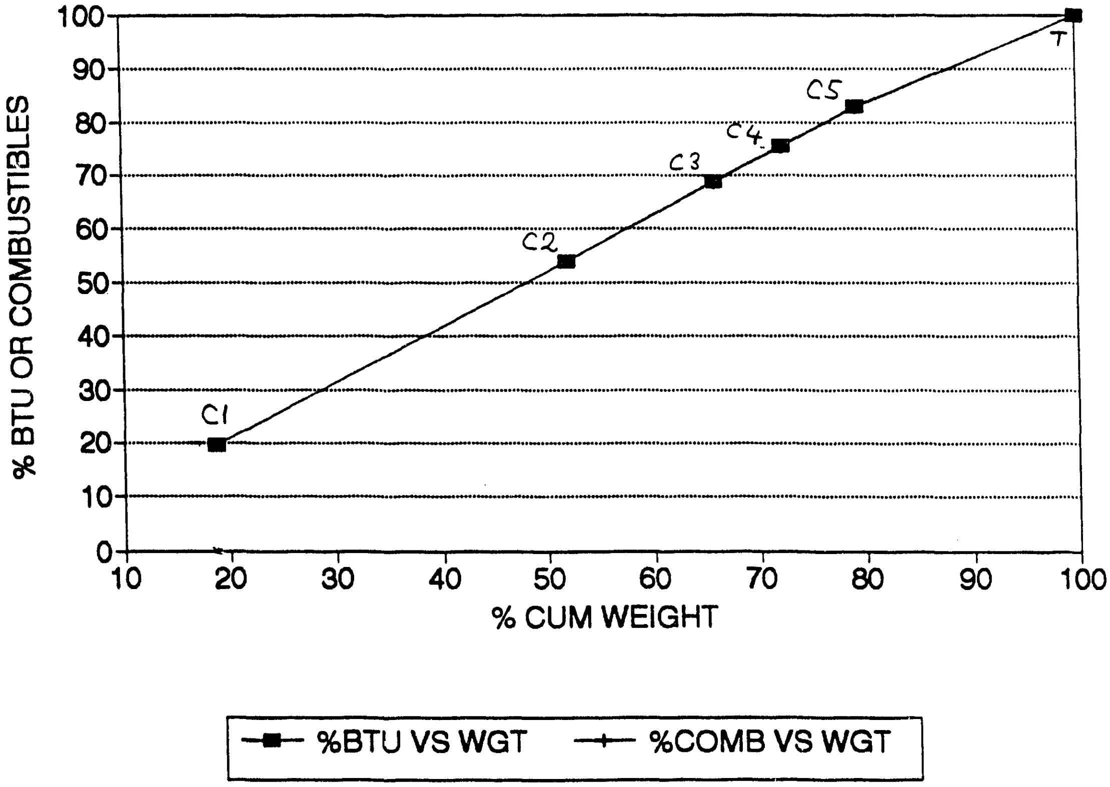

Figure 4. Washability curve for sample C32782 ground to -100 mesh showing cumulative %BTU or %combustibles vs %cumulative weight. These types of washability curves are used to construct 80%-BTU recovery composites for trace element analysis task.

need for further BTU analyses. The resulting trace element analyses from these 80%-BTU composite samples will indicate the possible beneficiation for each element at these generalized flotation conditions and mesh size used. It is not inferred that these conditions are the optimized conditions. The same generalized froth flotation conditions were applied to all coals for comparison purposes. For general optimized results each coal would have to be individually optimized and this is beyond the conditions or capability of this contract. A composite value of 80%-BTU (rather than 90%-BTU or some other value) was chosen because it was felt that, for the 34 samples tested, this figure would indicate a good range of beneficiation possible. In some samples certainly better or worse beneficiation is possible for the conditions tested.

Thus far all 34 samples of the -100 mesh coals have been processed. The chemical analyses for moisture, ash, and BTU have now been completed, and based on calculations from the data nine 80%-BTU composite samples have been prepared and submitted for trace element analysis. It is anticipated that the remaining 25 composite samples of the -100 mesh runs will be submitted soon, and the resulting analyses will be available in 3-4 months. These data will then be compared to trace element data obtained in the previous contract on the original feed coals.

Progress on Preparation and Flotation of -200 mesh Samples

Although all 34 samples have been ground and initially processed for release analysis, all the particle size and chemical analyses results have not been completed or confirmed. There are indications that up to 10 samples may have to be rerun under modified conditions since test results indicated excessive tailings (inferior yields) or the ground feed coal particle size distribution was not correct. Hopefully this can be corrected by addition of kerosene and less grinding times. Thus the results on -200 mesh samples will not be reported until the next quarterly report.

Progress on Preparation and Flotation of -400 mesh Samples

No significant progress has been made on these samples. This effort must be deferred until the -200 mesh work has been successfully completed. With the problems encountered so far with the -200 mesh samples it is anticipated (and recommended) that only select samples of -400 mesh sizes be run and that an alternative effort be directed towards more trace element mass balance characterization.

Progress on Trace Element Mass Balance Studies

No progress has been made on this task. It is planned to obtain trace element data for each fraction of at least one set of flotation products collected from one of the -100, -200, or -400 mesh flotation runs. This would include trace element analysis of each concentrate, combined tails, a split of the total water used for wet grinding, a split of final slurry water after grinding, and a split of combined slurry water from froth flotation runs. It is recommended that additional effort be allocated to understanding the mass balance of this complex system in lieu of some of -400 mesh runs that were originally planned.

CONCLUSIONS AND RECOMMENDATIONS

Splits of all 34 project samples that were ground to about -100 mesh size were cleaned by froth flotation using a release analysis procedure.

The data from release analysis are used to construct a series of washability curves that show various flotation results such as ash and S rejection or the recovery of BTU, combustibles, or weight of clean products. Thus far flotation products from all 34 -100 mesh coals have been analyzed for ash, moisture, and BTU.

From a washability curve that shows the plot of % cumulative BTU or combustibles vs % cumulative weight, composite samples each having 80% of the total BTU were prepared. Nine of 80% BTU recovery composites have been submitted for trace element analysis. It is anticipated that the remaining 25 composite samples from the -100 mesh runs will be submitted soon, and the resulting trace element analyses will be available in 3-4 months. These data will then be compared to trace element data obtained in the previous contract on the original feed coals.

Although all 34 samples have also been ground to -200 mesh size and initially processed for release analysis, all the particle size and chemical analyses results have not been completed or confirmed. There are indications that up to 10 samples may have to be rerun under modified conditions since test results indicated excessive tailings or the ground feed coal particle size distribution was not correct. Hopefully this can be corrected by increasing the amount of reagent used and decreasing grinding times. The results on -200 mesh samples will be included in the next quarterly report.

The effort on -400 mesh work will be deferred until the -200 mesh work has been successfully completed. With the problems encountered so far with the -200 mesh samples it is anticipated (and recommended) that only select samples be run on -400 mesh samples. It is also recommended that resources saved by omitting some of the -400 mesh runs be directed towards more trace element mass balance characterization.

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